53. (Unchanged) The apparatus of claim 16 wherein said non-imaging optical concentrator is a compound parabolic concentrator.

54. (Unchanged) The apparatus of claim 3 wherein said second non-imaging optical concentrator is a compound parabolic concentrator.

REMARKS

Claims 2-31 and 48-54 are pending in this application. Claims 2-31 and 48-54 have been rejected. Claims 8 and 24 have been amended. No claims have been canceled and no new claims have been added. Upon entering the proposed amendment, claims 2-31 and 48-54 will be pending in this application. No new matter has been added.

I Formal Matters

Objections to the Drawings under 37 CFR 1.83(a)

The Examiner has objected to the drawings under 37 CFR 1.83(a), stating that the drawings must show every feature of the invention specified in the claims. The examiner has stated that the "set up of claim 4 must be shown" and that "no new matter should be entered."

A new Fig. 7 has been added to overcome the Examiner's rejection under 37 CFR 1.83(a) requiring that "the set up of claim 4 must be shown." The specification has been changed to correctly correspond to the newly added Fig. 7. Since the description of the set up of claim 4 was provided in the original specification on page 30, lines 4-12, and since the newly added Fig. 7 is only added based upon the Examiner's request and since it is supported by the description provided in the original specification on page 30, lines 4-12, no new matter is added. These changes to the specification are described below.

Amendments to the Specification

The specification has been amended to reflect and correspond to the newly added Fig. 7. More specifically, the detailed description in the specification on page 30, lines 4-12 has been changed, by the insertion of reference numbers, to provide for a cross reference

between the newly added figure showing the set up of claim 4 and the originally disclosed description of an embodiment of the invention as recited in claim 4.

No new matter has been entered. Applicant believes that the description provided in the original specification on page 4, lines 4-12 provided a detailed description of the set up of claim 4 and the description has only been changed to include reference numbers which correspond to a figure which has been added at the request of the Examiner which must show the set up of claim 4. The Applicant submits that the content of the drawing is evident from the written description and the other drawings. If the Examiner believes that this additional figure and changes to the specification to accommodate this figure are new matter, Applicant requests the withdrawal of the portions of the amendment that relate to the addition of the Fig. 7.

II Claims Rejected on Substantive Grounds

Rejections Under 35 U.S.C. 112

Claims 2-31 and 48-54 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. More particularly, the Examiner has the following rejections, which are each addressed below.

(i) Description of the word "Port"

One basis for the Examiner's rejections of claims 2-31 and 48-54 for being indefinite is that the "description of the word ports are misleading and incorrect." More particularly, the Examiner provides that "ports as described, where present in the claims, can be mistaken for a connection device coupling the non-imaging optical waveguide to the optical fiber, when they are in fact the openings in the non-imaging waveguide that allow the light to pass through." The Examiner's rejection appears to be based on the notion that a port in a non-imaging optical waveguide which is an opening in the non-imaging optical waveguide cannot also serve as a connection device coupling the non-imaging optical waveguide to other optical devices such as the optical fiber or a non-imaging optical concentrator.

The word "port" as described and recited in the claims is meant to be both an opening that allows light to pass through and an opening that is adapted to be coupled to an optical fiber - i.e. a connection device. As recited in nearly every claim, the term port is used to define an opening which is "**connected**" to the waveguide so as to act as a port for light rays to pass through the apparatus (e.g. see claims 2, 4, 8, 12, 17, 25, 26, 27, 28 and 48) and the term port is also used to define a connection device when the terms such as "**connected**" or "**adapted to be coupled**" are used in conjunction with the word "port."

For example, please refer to the specification on page 13 lines 30-35 where it reads: "a rectangular input surface would connect to the fiber optic..." As can be inferred from this sentence, a port is an opening (input surface) through which light passes, and in this case, input surface 32 is the port. The specification further provides that input surface 32 would connect to the fiber optic, hence clearly setting forth that the port besides being an opening, can be adapted to serve as a connection device.

The word port as used by the Applicant and as recited in the claims is meant to convey the two non-exclusive definitions of the term, namely that ports are not only openings in the non-imaging waveguide that allow light to pass through, but they are also elements of the claimed invention that are capable of acting as connection devices connecting the waveguide to other optical devices. The applicant therefor believes that the Examiner's rejection to the use of the word "port" is overcome.

(ii) Description of the term "Non-Imaging Optical Concentrator"

Another basis for the rejections of claims 2-31 and 48-54 for being indefinite as stated by the Examiner is that the "non-imaging optical concentrator can be misunderstood to be a separate item of the optical setup when it is in fact a physical part of the non-imaging optical waveguide."

The phrase "non-imaging optical concentrator" is recited in independent claims 2, and 12. In these claims the non-imaging optical concentrator is recited as a separate item coupling an optical fiber to a first port of a corner-turner. As it is recited in these claims, the non-imaging optical concentrator is indeed a separate item. This notion that the concentrator is a separate item is supported for example, in the specification describing different embodiments

of the present invention, where some embodiments use a non-imaging optical concentrator and some don't. The "non-imaging optical concentrator" when used in embodiments of the present invention is used for delivering a beam of light having a divergence half-angle of 90 degrees. For example see Fig. 3 and its supporting description beginning on page 25, line 10 of the specification, which describes a corner turner setup that does not use a non-imaging optical concentrator and see Fig. 4 and its supporting description beginning on page 27, line 1 of the specification, which describes a corner turner that uses a non-imaging concentrator.

As described in the specification, the non-imaging optical concentrator may be a compound parabolic concentrator (CPC) or any other optical concentrator known in the art. The waveguide of the present invention may require the use of a concentrator when the waveguide is configured to work with light received from a fiber optic bundle that has a divergence half-angle of less than 90 degrees. The waveguide of the present invention may not require a concentrator when the divergence half-angle of the light being received by the waveguide is 90 degrees. For example, in claims 2 and 12 where the light is received from a bundle having a divergence angle of less than 90 degrees, a concentrator is recited, and where a concentrator is not a necessary element, as in other claims such as claim 4, it is not recited.

In addition, please refer to the specification on page 14, lines 29-30 where the specification provides: "the corner turner output may be as far as desired from the CPC exit." This language and other similar ones clearly establish that the non-imaging optical concentrator is a separate item that can be made to be an integral part with the corner turner. For example, the specification on page 14 lines 12-15 recites that the "input portion of the reflector is a compound parabolic concentrator." Also see the specification on page 16 lines 31-35 describing "the input CPC" portion. These descriptions establish that the concentrator is a separate piece.

The reason that the present invention optionally uses a non-imaging optical concentrator is to remove a bending angle limit that may exist with these corner turners. A form of this limit is described on page 14, lines 3-6 of the specification. As described in the specification, in any system where there is low divergence angle, the maximum bending angle of a light beam in a corner turner may be limited. For these systems where the bend angle is limited, two solutions are taught. One solution is to accept the divergence angle imposed

limitation on the maximum bending angle and hence make up the desired turn by combining allowable maximum turns. For example, see Fig. 3, and its corresponding description beginning on page 25, line 10 of the specification for an embodiment of a corner turner setup that does not use a non-imaging optical concentrator.

Another solution for addressing the maximum bending angle limitation is to address the source of the limitation which is the divergence angle itself. This other solution, is one that involves an increase in the divergence angle by passing the light through a concentrator to increase the divergence angle of the beam of light which is incoming to the bending device. For example, see Fig. 4 and its corresponding description beginning on page 27, line 1 of the specification for an embodiment of a corner turner that uses a non-imaging concentrator.

Lastly, please refer to the discussion on page 29 lines 4-6 where specification states that "several embodiments have employed CPC's to transform beams of low NA to beams whose NA is 1.0." Furthermore, the specification on page 29, lines 9-14 provides that: "corner turner systems using such CPCs, or other optical concentrators may be advantageous in producing more easily fabricated corner turner structures, e.g. structures which do not require elliptical surfaces on the inner sides of the surfaces or structures which achieve a desired turning of the light beam in one turn i.e. 90 degree turn in a single swept bend. Therefore, Applicant believes that the use of the phrase "non-imaging optical concentrator" will not be misunderstood. The concentrator is a separate item of the optical setup. It may in fact be a physical part of the non-imaging waveguide, but as described above, it does not necessarily have to be. Accordingly, Applicant believes that the Examiner's rejection directed to the term "non-imaging optical concentrator" is overcome.

(iii) Description of Sections Parallel to the Plane of said Corner is Unclear

Another basis for the Examiner's rejections of claims 2-31 and 48-54 for being indefinite is that the "description of the sections parallel to the plane of said corner is unclear, where present in the claims, since neither the sections nor the plane are defined..." The phrase "sections parallel to the plane of said corner" appears in independent claims 8, 17 and 24 and in dependent claims 6, 13, 15, 16, 18, and 19. Applicant respectfully submits that almost all

three-dimensional objects have a dominant plane and every geometric shape can have sections. The rejection is focused by the Examiner's statement that neither the sections nor the plane are defined. In response, Applicant respectfully submits that sections and planes are inherently present in every geometric shape, and those possessing ordinary skill in the relevant art are quite fluent in recognizing planes and sections in optical devices. More specifically, the description on page 13, lines 26-35 of the specification in describing the geometry of Fig. 1D clearly defines both the plane of the bend and sections parallel to that plane.

Lastly, the Examiner in stating his 102 rejections, discussed below, uses language describing the Fig. 11 in the cited art in terms of "sections parallel to the plane of the bend." Applicant argues that the phrase "section parallel to the plane of said corner" as used in the specification and present in the claims relies on the same inherent definition used by those of ordinary skill in the optical arts and which has also been used by the Examiner. Accordingly, Applicant believes that that description of "sections parallel to the plane of said corner" where present in the claims is not unclear and hence based upon the above discussion the Examiner's rejection is overcome.

(iv) Manner in Which They Are Identical is not Mentioned (i.e. sections are identical)

Another one of the rejections under 35 U.S.C. 112 is based on the Examiner's statement that "the manner in which they are identical is not mentioned...." Applicant believes that the Examiner does not fully appreciate the "2d" and "3d" embodiments of the claimed invention. A review of the specification describing Figs. 1 and 2 establishes that in "2d" corner turners, sections parallel to the plane of the corner are identical. Therefore, embodiments that claim a "2d" corner turner recite the fact that sections parallel to the plane of the bend are identical, as for example recited in dependent claims 15 and 18.

However "3d" corner turners, for example, as shown in Fig. 5 and as described beginning on page 27, line 23 of the specification will not have sections parallel to the plane of the corner that are identical. Accordingly, when a claim is directed towards a non-2d corner turner, there are no recitations that limit the sections parallel to the plane of the corner to be

identical. Therefore, Applicant respectfully submits that all section parallel to the plane of the corner are not identical, and accordingly believes this rejection to be overcome.

(v) Upper and Lower Surfaces of the Waveguide are not Defined

The Examiner also rejects the claims under 35 U.S.C. 112 as being indefinite because the "upper and lower surfaces of the waveguide are not defined." The terms "upper" and lower" surfaces of waveguides are recited in independent claims 8, 15, 18 and 48. As used in these claims the upper and lower surfaces of the waveguide are described as planar reflective surfaces. Applicant respectfully requests that the Examiner consider that as is generally known to those having ordinary skill in the optics art, a waveguide typically has a surface bounding it and that any three-dimensional shape - such as a waveguide- inherently has an upper and a lower surface. This inherent definition related to the upper and lower surfaces of the waveguide and also they being planar reflective surfaces is defined in the specification on page 13, lines 30-31 in describing the geometry of Fig. 1D. Applicant therefore, believes that the Examiner's rejection directed to the indefiniteness of the "upper and lower surfaces of the waveguide" is overcome.

(vi) Unclear How There Can Be Planar Reflective Surfaces in Two Sections of a Parabola and How a Corner is Formed in the Parabolic Sections

The Examiner has rejected all pending claims under 35 U.S.C. 112 because according to the Examiner "it is unclear how there can be planar reflective surfaces in two sections of a parabola, and similarly how a corner (generally understood to contain a right angle) is formed in the parabolic sections." In addressing the Examiner's rejections, first the question of how a corner is formed from parabolic sections is addressed, and then the issue of how the planar reflective surfaces are integrated thereto are explained.

1. Corner Formed from Parabolic Sections

Applicant respectfully request from the examiner to refer to the specification on page 18, line 10 through page 20, line 20 and page 20, lines 21 through page 24, line 16 for a description of the construction steps for an embodiment of the optical corner turner of the

present invention which has parabolic sections. Fig. 2 and the corresponding description show that the outer curved reflective section of the optical corner turner is formed by the joining of two parabolas, each starting from an end of the corner turner, by an ellipse. This description shows how a corner turner is made from parabolic sections.

2. Planar Reflective Surfaces

Having described above, how a corner is formed using parabolic sections, Applicant will now explain how planar reflective surfaces coexist with the two parabola sections. As described in the specification on page 5, lines 11-17, an aid to the visualization of such a 2d corner turner is a curved 90 degree bend in a rectangular-cross-section air conditioning duct. Such a duct is made from four surfaces: (1) an inside of the turn surface, (2) an outside the turn surface, (3) an upper flat (planar) surface and (4) a lower planar surface. The flat upper and lower surfaces meet the curved surfaces at their respective edges.

Turning now to the corner turners in the claimed invention, it should be recognized first of all, that planar reflective sections are not constructed from parabolas - curved reflective sections are. As explained above, the planar reflective surfaces exist in 2d corner turners. The planar reflective surfaces are a pair of flat (planar) surfaces that are the upper and lower surfaces of the waveguide. It then follows that, the curved surface made from the parabolic sections is the outside of turn surface as shown in Figs 1I, 1J or 2. The inside of turn surface as shown in Figs 1I and 1J is also a flat surface, although it does not have to be. The two inside of turn and outside of turn reflective segments meet the planar reflective surfaces at their respective edges and make up the four surfaces that bound the waveguide.

In light of the above discussions, Applicant believes that the Examiner's rejection directed to the indefiniteness of the "planar reflective surfaces and parabolic sections" has been clarified and the rejection is therefore overcome.

Lastly, if the Examiner believes that the claimed invention is still indefinite, Applicant offers to copy into the language of the specification original claims to the extend that such copying would remove any indefiniteness from the invention as claimed.

Rejection Under 35 U.S.C. 102(b)

Claims 2-11, 25-31, 51 and 54 are rejected under 35 U.S.C. 102(b) as being anticipated by Jannson et al., U.S. Patent No. 4,898,450. Before distinguishing the claimed invention from the cited art, a brief overview of the invention is in order.

Brief Overview of the Claimed Invention

The present invention relates to a suite of devices that efficiently change the direction of a beam of light in a non-imaging application. The invention utilizes non-imaging optical constructions whose purpose is the efficient transfer of optical power from one place to another, with minimal loss in the concentration of that power, and with no need to retain image qualities. These non-imaging devices are particularly useful in changing the direction of light that is carried by optical fibers, although they may also be useful in any optical system requiring the redirection of a light beam. Embodiments of the present invention provide a device to efficiently turn light from an optical fiber around a corner while avoiding the loss that would occur if the fiber were bent.

Embodiments of the present invention include corner turners that have curved reflective surfaces. The curved reflective surfaces may be made from segments that could be circular, elliptical or hybrid segments made from combining parabolic segments with elliptical ones. Additionally, the present invention, by recognizing that most light from a fiber optic source will have divergence half-angles less than 90 degrees, achieves a practical solution using non-imaging corner turners in conjunction with non-imaging optical concentrators. Accordingly, in alternate embodiments, the present invention combines corner turners with non-imaging optical concentrators that could be tuned to receive light from optical fibers having divergence half-angles less than 90 degrees. The combined corner tuner and concentrator embodiments provide a compact device for efficiently changing the direction of light that is carried by optical fibers.

The Cited Art

The Jannson et al. invention is directed towards a fiber optic connector. For example, see the Jannson et al. abstract that recites starting with "there is disclosed an expanded beam fiber to fiber connector, based on non-imaging optic principles for coupling

light beams from one optical fiber to another." The abstract recites further that "the system consists of two identical connector parts." Additionally, the abstract also recites that "... a lens may be located...." at the connection between the two connectors. The Jannson et al. patent is directed towards a non-imaging fiber optic beam to beam connector. For example, see col. 3 lines 8-14 where the Jannson et al. patent provides that "the non-imaging connector which is the subject matter of the present invention has a higher tolerance to angular misalignment than prior art systems based on imaging optics." Also see col. 7, lines 14-16 again referring to an example of the non-imaging connector of the present invention. More particularly, the Jannson et al. invention deals with developing the contours of the side walls and front and exit surfaces for connectors, which are two identical parts (see col. 3, lines 55-56). The Jannson patent is related to methods for having non-imaging back-to-back connectors for connecting poorly aligned optical fibers that have a higher tolerance to angular misalignment than prior art systems based on imaging optics.

The Cited Art Distinguished

The Jannson et al. patent does not teach non-imaging devices for bending light from fiber optic cables around a corner in an efficient and compact manner. On the other hand, Fein, in the present invention, teaches a suite of devices for the efficient and compact turning of light around a corner from one optical fiber to another.

Turning now to the portions of the Jannson et al. patent relied upon by the Examiner as a basis for his 35 U.S.C. 102(b) rejections, Applicant respectfully restates that the Jannson et al. patent does not teach efficient non-imaging optical corner turning. The Examiner relies heavily on the language describing the arrangement of Fig 11. The Jannson et al. patent clearly calls the device of Fig 11 a four port directional coupler (see col. 7, lines 29-30). The entire disclosure that could be presumed to relate to the corner turning teachings are contained in one sentence where the Jannson et al. patent recites "input beams can be split into output beams by means of a suitable half-mirror..." (see col. 7, lines 31-32). Nowhere else does the Jannson patent teach anything related to any device other than a "non-imaging connector" which is the subject matter of the Jannson et al. patent. Applicant believes that the use of the phrase "suitable half-mirror" is merely precatory.

The mere presence of the sentence citing a "a suitable mirror" is a testament to the lack of knowledge related to such a device. A statement directed to a suitable mirror begs the question of "what is a suitable mirror that would work efficiently and in a compact manner?" The Jannson et al. patent does not teach what a suitable mirror is, and/or how one would go about making such a device. However, the present invention is entirely focused on teaching a suite of devices for the efficient and compact turning of light around a corner from one optical fiber to another. Besides clearly distinguishing the present claimed invention (an efficient non-imaging optical corner turner) from the cited art (a non-imaging optical connector) as set forth above, the Applicant also provides two additional alternate theories for interpreting the teachings of Jannson et al. and distinguishing the claimed invention from this cited art. These interpretations are that: (1) the cited art device is not optically efficient, and (2) the cited art device uses imaging devices, and hence is not a purely non-imaging device.

Turning to the first interpretation, Applicant submits that a visual inspection of Fig. 1 of the Jannson et al. patent shows that upon exit from the collimator, light rays may exit with a divergence angle of θ_2. Light rays exiting the collimator at any θ_2 greater than zero have the possibility of missing their target surface, which could be a mirror image of Fig. 1, for example as shown in Fig. 4. Since light rays could miss the target surface, the arrangement of Fig. 1 cannot be optically efficient. This lack of optical efficiency clearly distinguishes the present claimed invention from the Jannson et al. patent.

Turning now to the second interpretation, Applicant submits that the Jannson et al. device uses imaging elements to address the potential inherent inefficiencies of its connector. The arrangement for a connector shown in Fig. 2 of the Jannson et al. patent shows a "lens-type front surface" to increase the overall optical efficiency of its system. The lens is used to focus the light rays onto the receiving surface. Here, Jannson et al. is using imaging optical devices such as a lens to increase the efficiency of its in-line beam-to-beam connector. However, the present claimed invention is able to achieve efficient corner turning without resorting to the use of lens-type imaging devices. The absence of a lens in the present claimed invention further distinguishes it from the Jannson patent.

III Claims Amended

Claim 8 has been amended to overcome a potential 35 U.S.C. 112 rejection. The term "the bend" has been replaced with "said corner" so that claim 8 uses terminology consistent with other independent claims.

Claim 24 has been rewritten in independent form to incorporate the limitations of claim 17. Support for the amended claim 24 is provided in the specification beginning on page 25, lines 8 and continuing to page 26, line 15 which describes the setup of Fig. 3.

CONCLUSION

In view of the foregoing, Applicant believes all claims now pending in this Application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 650-326-2400.

Respectfully submitted,

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